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**JOHN F. KENNEDY SPACE CENTER  
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**ANALYSIS OF THE 60-Hz POWER SYSTEM AT KSC -  
THE ORSINO SUBSTATION**

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## **ABSTRACT**

**An analysis of the Orsino Substation, a component (50%) of the 60-Hertz electric power system at the Kennedy Space Center, is presented. This report contains separate single-line diagrams of the sixteen feeder circuits to permit easy access to information on the individual feeders for future planning. The load condition of each feeder and load break switch are presented and a heuristic reliability analysis of the system is performed. This report contains information about the system organized in a useful fashion for decision making purposes. The beauty of it is in the simplified manner by which information about the system can be obtained.**

## **SUMMARY**

**The various feeder networks comprising the Orsino Substation are decoupled and presented in easy-to-read diagrams without any loss of information. The connected loads to each load break switch (LBS) are computed to determine the exact load conditions of each LBS and feeder. These data are compared to the demands, a useful information for power coordination and growth planning. The load connected to each primary transformer is also compared to the demand and to the size of the transformer. The Study shows that, though the system is still very healthy, a systematic planning should be instituted. Hitherto, load has been added arbitrarily or perhaps based on geographic convenience. This cannot continue indefinitely if an optimal lifetime and performance of the system is to be expected.**

## **I. INTRODUCTION**

### **1.1 Purpose**

The 60-Hertz electric power system at the Kennedy Space Center (KSC) is described in [1] the GP-900 document. This document, the authors point out, is for the benefit of present and potential users of the power system to help them determine whether their requirements can be met adequately or not. It, therefore, identifies the facilities and the types of power available to them in pursuant to the objectives of the system.

The focus of this paper is different. It is for the attention of the NASA/KSC staff whose functions might include a managerial role in the system expansion planning and reliability evaluation. This paper is also directed toward the system planners and operators and those responsible for system reliability. Much of the information contained in this paper is derived from [2] - the system one-line diagrams document 79K17429. The purpose of this paper is to provide an easy reference and guideline to the NASA staff overseeing system planning when making a decision on adding (or deleting) components to the system. This document is also invaluable for a quick appraisal of the system's load conditions and reliability status. There is a tremendous reduction in effort and time in obtaining information from this paper as compared to doing the same from the one-line diagram document 79K17429.

### **1.2 Scope and Methodology**

This report describes and evaluates only one of the two substations comprising the 60-Hertz electric power distribution system at KSC - the Orsino Substation. This Substation is decoupled, and the Study is done on a feeder-by-feeder basis. A one-line diagram of each feeder in normal configuration is drawn. It is, hence, easy to describe and evaluate the electrical status of the isolated feeder. Both the diagrams and the tables showing the load conditions and a somewhat heuristic assessment of the reliability at various load points are useful tools for decision making.

### **1.3 Assumptions**

The protective devices such as fuses, reclosers, and circuit breakers are assumed to be perfect and known. They are thus omitted in the diagrams (for the most part) so as to enhance clarity and for easy perusal which is a chief objective of this paper.

The feeder diagrams depict the normal configuration status of the individual feeders, i.e., in drawing the one-line diagram of a given feeder, the entire system is assumed healthy.

The load connected to a substation (transformer) cannot exceed the KVA rating of the substation.

The primary voltage of all the substations is understood to be 13.2 KV, and the secondary voltages of the substations are irrelevant to the assessment of the reliability conditions of a load break switch (LBS). Thus, these pieces of information are omitted in both diagrams and tables. Furthermore, they are easily assessable and readily available from other existing documents.

## **II ORSINO SUBSTATION BRIEF DESCRIPTION**

### **2.1 General**

The Orsino substation generally referred to as the industrial area substation is described in the GP-900 document. As is the general intent of that document the description is with regards to the facilities served by the substations rather than its configuration. To determine the margin between available power and demand, it is important to know what feeders are connected to a given transformer in the distribution station. The description that follows is given in the order depicted in the systems one-line diagram, document 79K17429. This description is also an attempt to simplify the diagram.

### **2.2 Substation Transformers and Assigned Feeders**

The six individual transformers in the Orsino distribution station supply power to the following feeders under normal configuration.

**T6: 10000/12 500 KVA, 3-0, 115 KV/13-2 KV**

**Supplies feeder 206**

**T5: 1000/12 500 KVA, 3-0, 115 KV/13-2 KV**

**Supplies feeders 211, 207, and 201**

**T4: 1000/12 500 KVA, 3-0, 115 KV/13-2 KV**

**Supplies feeders 210, and 202//203**

**T3: 10000/12 500 KVA, 3-0, 115 KV/13-2 KV**

**Supplies feeders 208, 209, 212 and 204//205**

**T2+T1: 5000 KVA, 3-0, 115 KV/13-2 KV**

**Supply feeders 101, 102, and 103.**



### III METHOD OF INVESTIGATION AND DESCRIPTION OF DATA

#### 3.1 Feeder Single Line Diagrams

The preliminary drafts of the separate one-line diagrams of the individual feeders were drawn from the system one-line diagram - 79K17429 document. This was done by tracing the loads of each feeder from the distribution station (M6-996) through the load break switches connected to it to the various loads and interconnection points with other feeders. To determine the load supplied by a feeder at normal configuration coordination board diagram was visited. Here the normally open (N.O) and normally close (N.C.) switches are shown. Using this information and from discussions with the power coordinators the final draft of feeder one-line diagrams were drawn.

This report arranges the feeder diagrams in the same order (from left to right) they are found in order documents and computer data base for the system. However, the present and normal configuration shows some redundant feeders (as two feeders in parallel) such as feeders 202//203, 103//212, and 204//205. In these cases only one diagram is shown for both feeders and which ever feeder between the two that is at a higher position in the arrangement (to the left of the other in the system one-line diagram) determines its position in this document, e.g. feeder 103//212 is figure number 9 because FDR 212 is the ninth item in the feeder data base though FDR 103 is the thirteenth item.

The following symbols and notations are represented in the diagrams.

-----o-----	Normally open (N.O)
#	Load Break switch member (LBS#)
(#)	Connector line number
#	Rated Load in KVA (Size of Substation)

The numbers shown in this report correspond to those assigned to the various components in other existing documents on the system.

#### 3.2 The Connected Load Data

Table 1 is a tabular description of the load conditions of the various load break switches connected to each feeder. These are presented on a feeder by feeder bases in the same order as the single-line diagrams. For a given feeder, the load break switches (LBS) are listed from bottom of feeder up to the distribution station transformers supplying power to the feeder.

The second column of table 1 shows the feeders connected to the LBS. If this column shows more than one entry for a LBS, the first entry is the main supply feeder (the

feeder under discussion) while the others are redundancies. The redundancies for a LBS are shown together with the LBS from which they are connected.

The third column of table 1 lists the LBS numbers to which the LBS under consideration is connected. The first of those LBS numbers is usually the bus from which the LBS under consideration draws power.

Column 4 of table 1 shows the load connected to the LBS. This is the sum total of the rated KVA of the transformers connected to the LBS either directly or through other LBS's. It will be observed that this figure increases as one goes up the ladder (down the column). Since some LBS's constitute loads for the preceding LBS. There may be more than one entry in this column. This happens when an LBS shares load with another LBS. The shared loads are denoted by superscript numbers which are explained below.

Explanation of superscripts:

1. The 1900 KVA Load is shared with LBS # 51 on feeder 201
2. The 2500 KVA Load is shared with LBS # 34 on feeder 201
3. The 325 KVA Load is shared with LBS # 23 on feeder 208
4. The 2500 KVA Load is shared with LBS # 59
5. The 1900 KVA Load is shared with LBS # 36 on feeder 211
6. The 150 KVA Load at LBS # 59 is shared with feeder 208 Via LBS #23
7. The 325 KVA Load is shared with LBS # 59

Column 5 of table 1 shows the redundancy ties of the LBS. The term "Failure" is used to indicate disconnection. It might be intentional - during planned switching - for instance, or unintentional as in the case of a fault. In any event the entries on this column show the additional load that will be connected to the LBS if a failure occurred above a designated LBS on designated feeder but no higher than the next LBS. Only single failures are considered, i.e. if more than one redundant line is connected to the would-be failed LBS, that case will not be considered. Simply, only inevitably added loads in the event of a failure are listed.

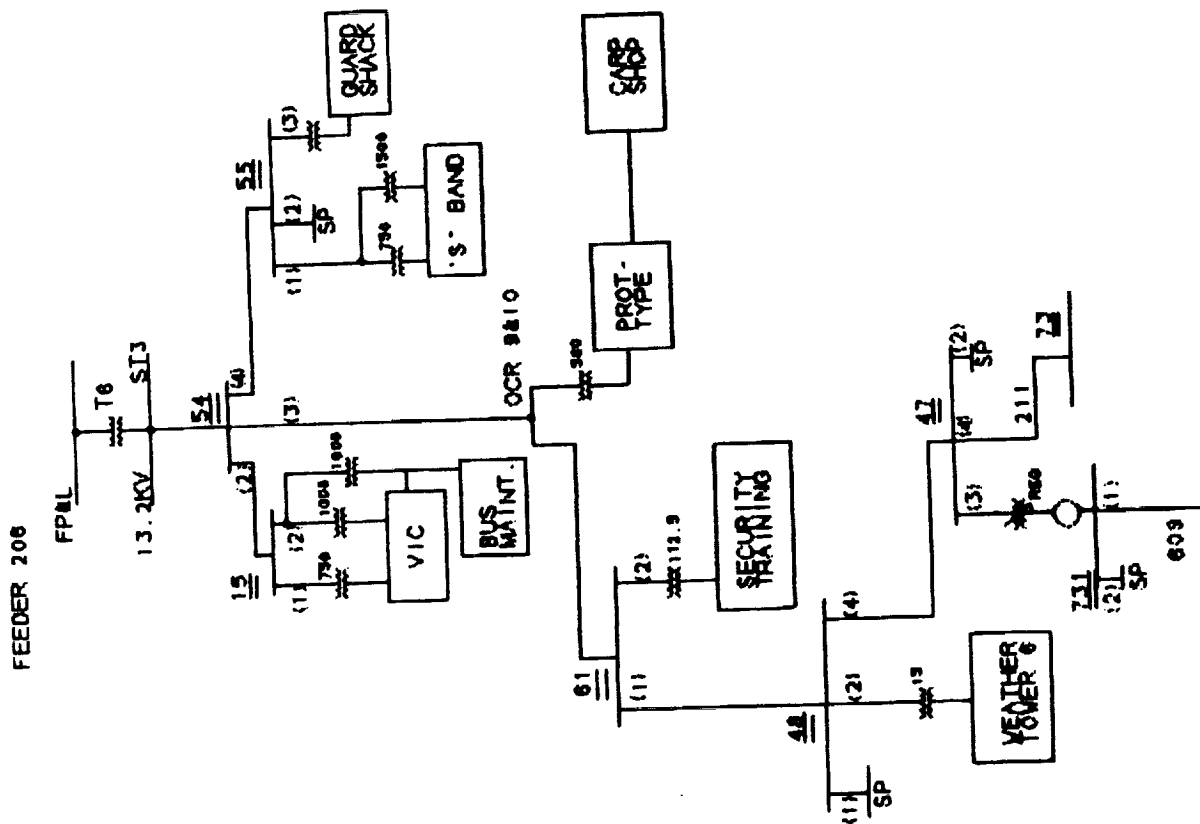


FIGURE 1

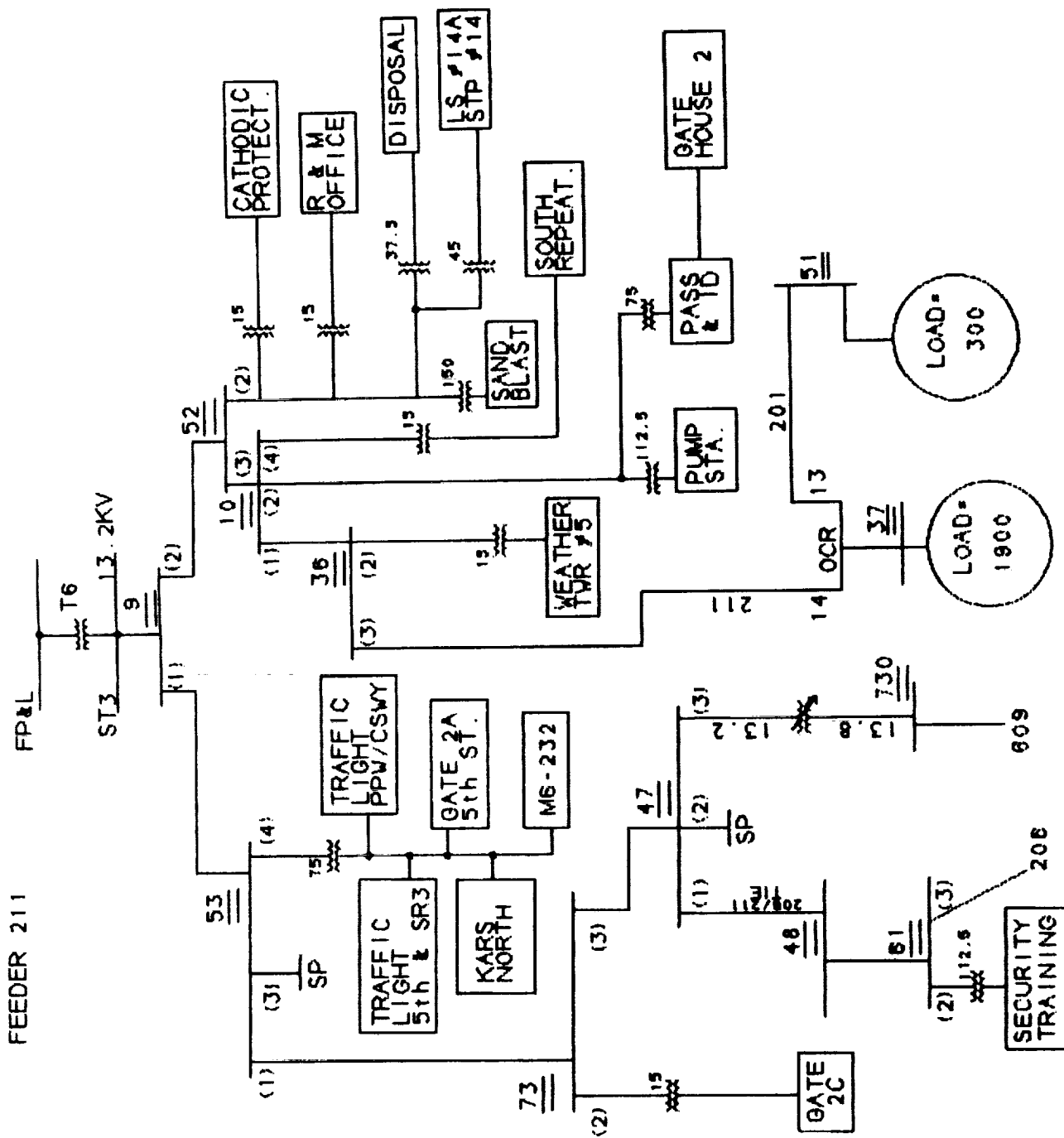


FIGURE 2

# FEEEDER 207

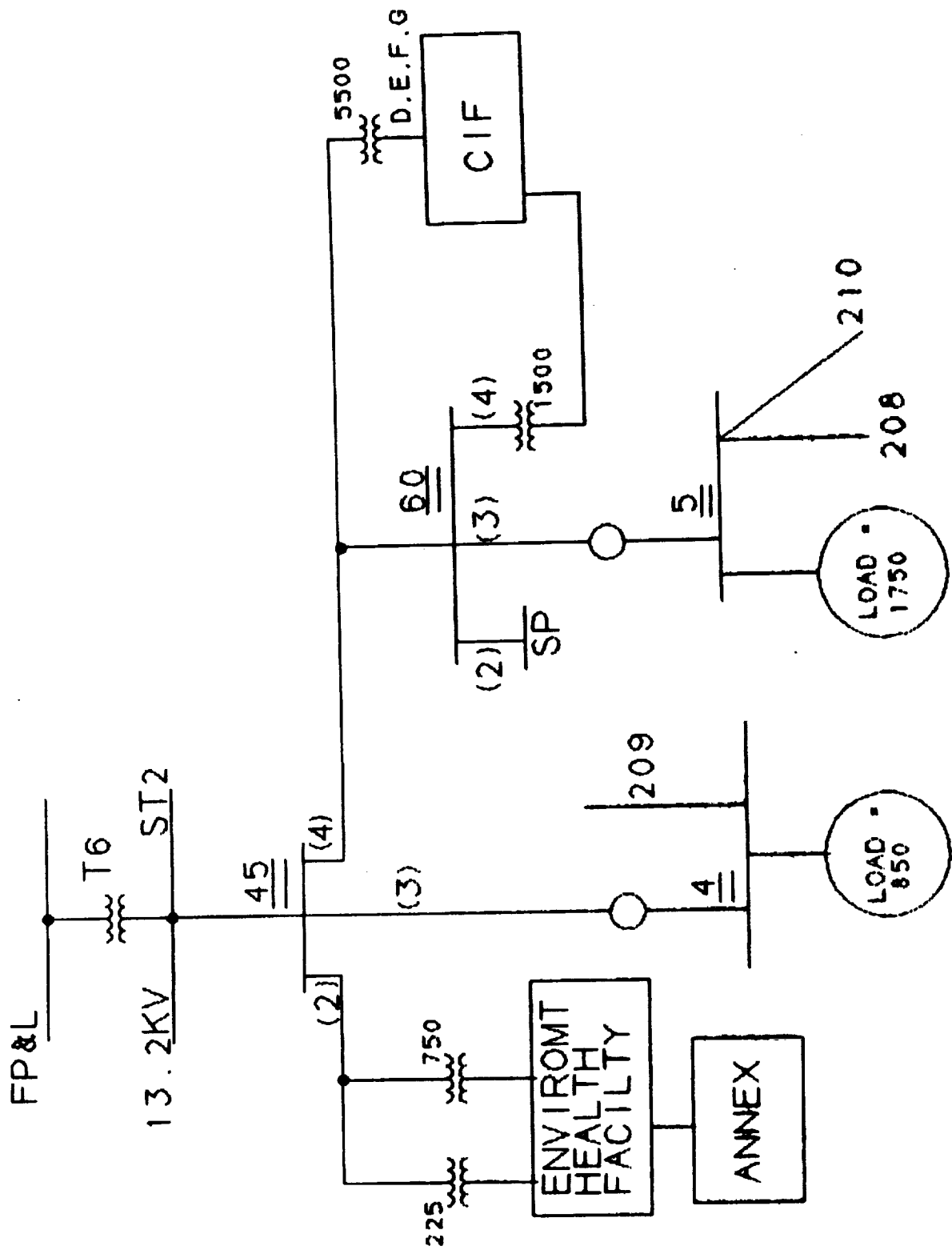
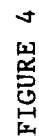


FIGURE 3





140



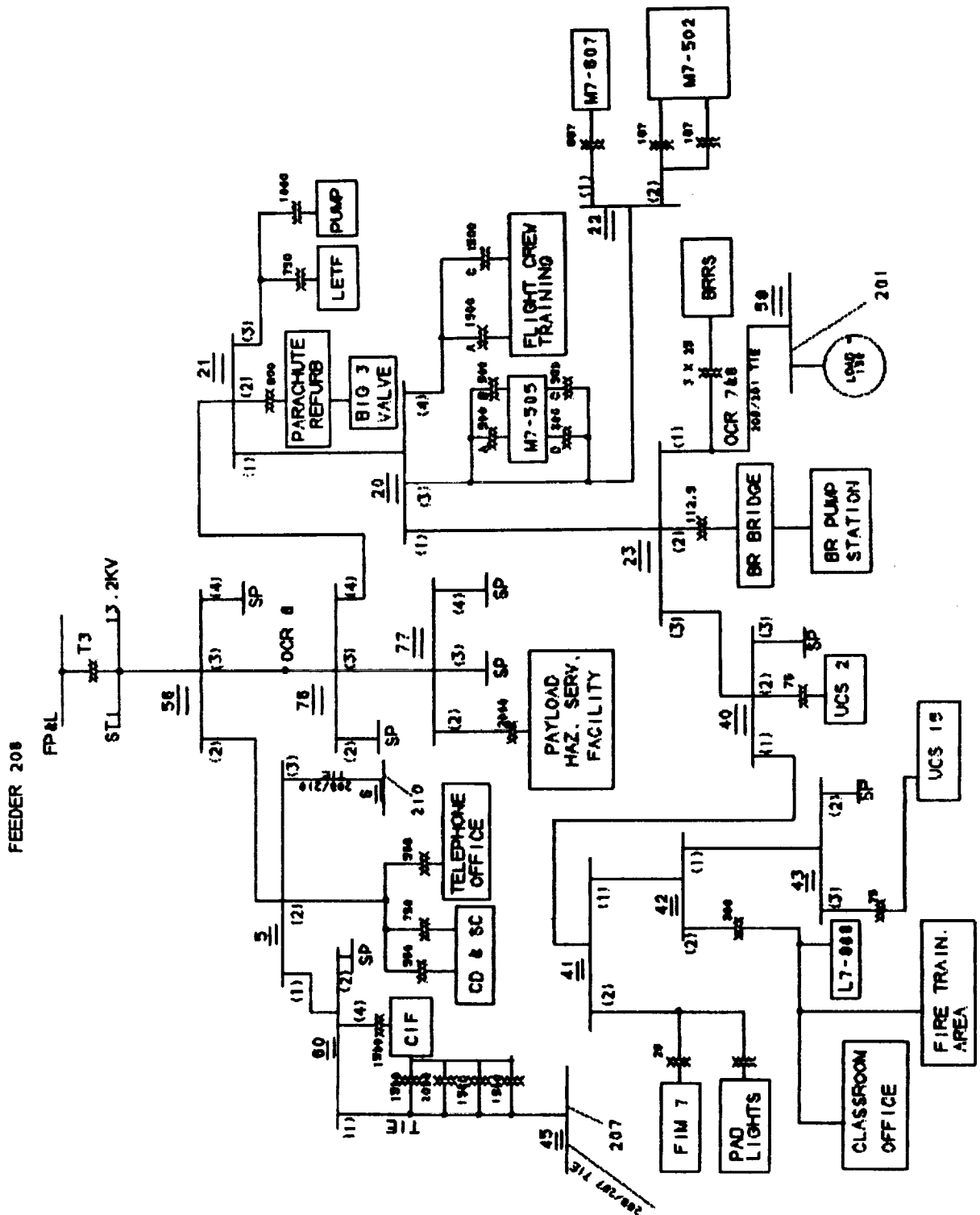


FIGURE 7

[illegible]

# FEEDER 103/212

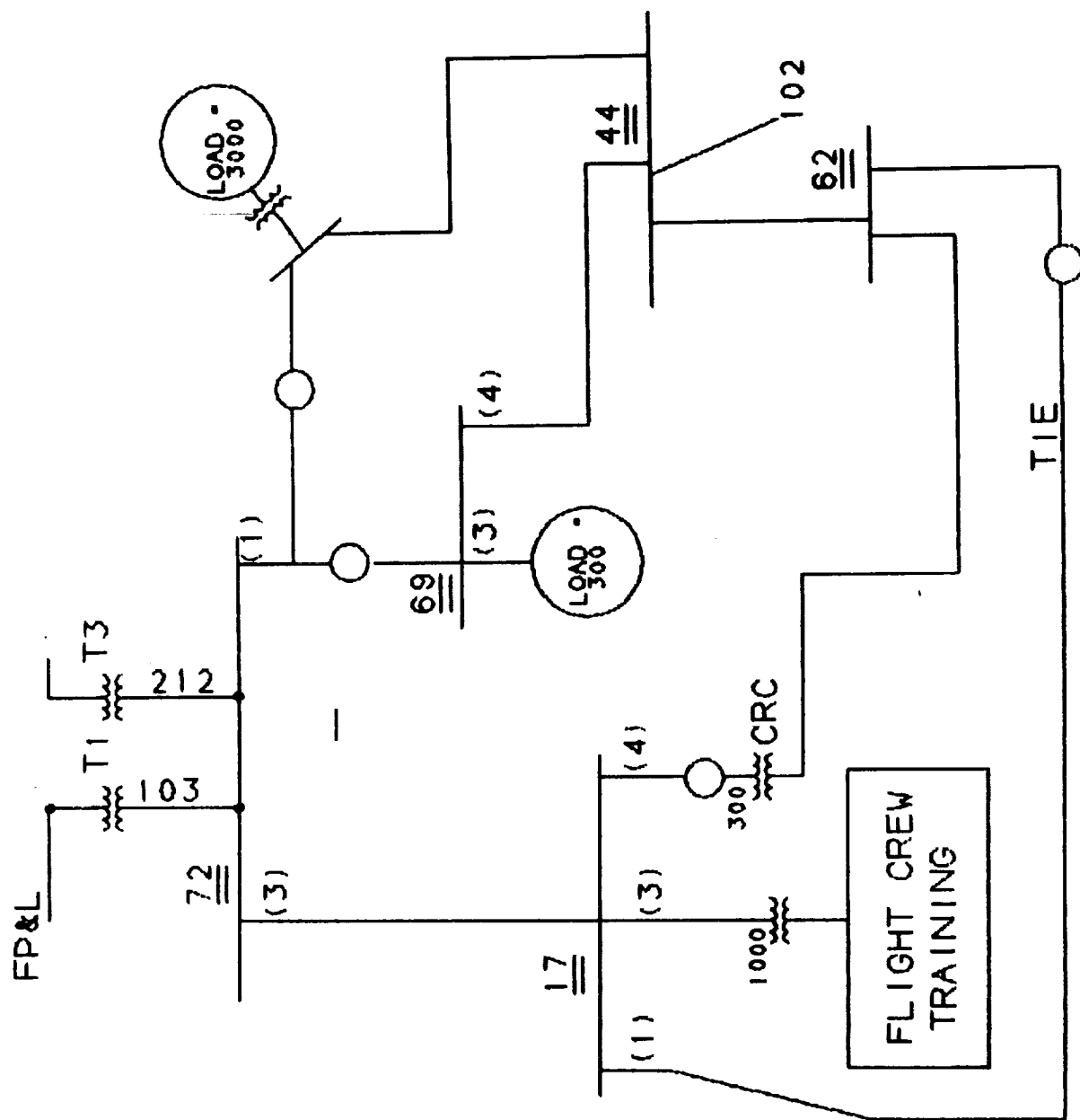


FIGURE 9

202/203

FEEDER 101

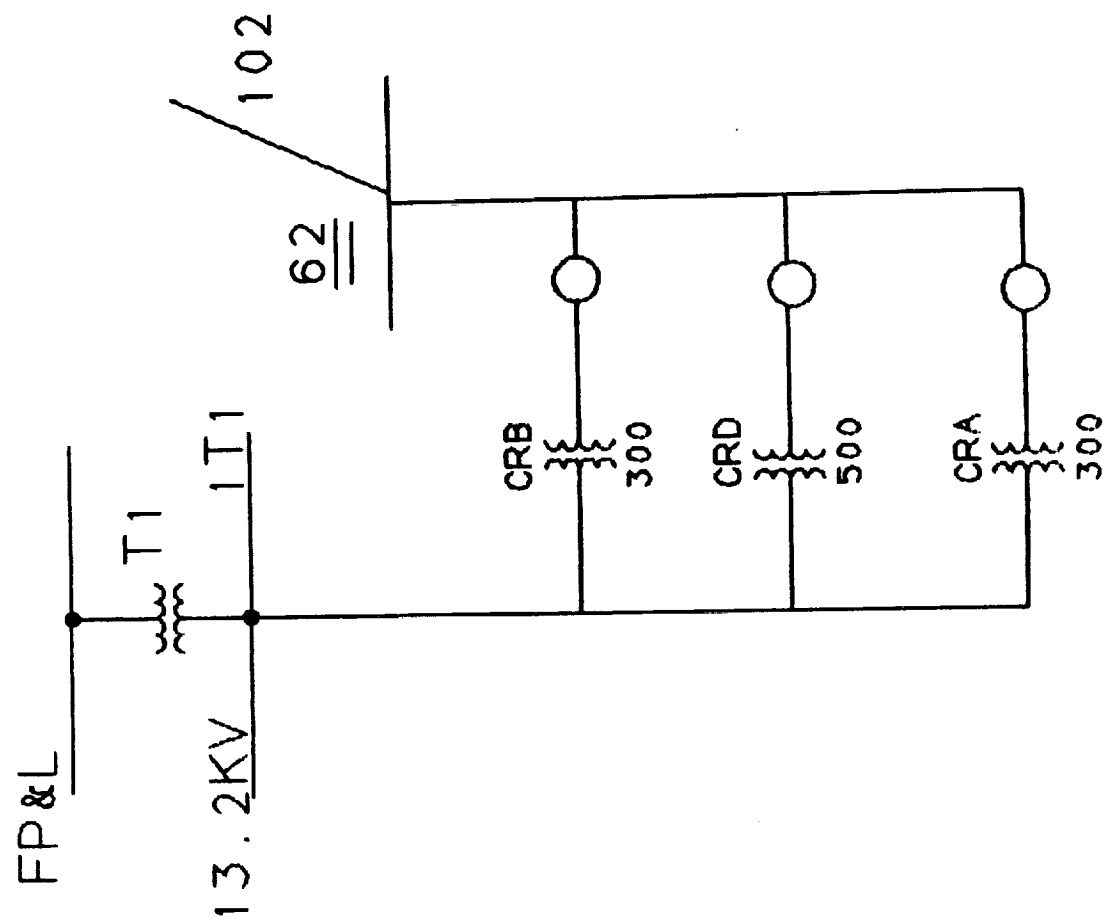
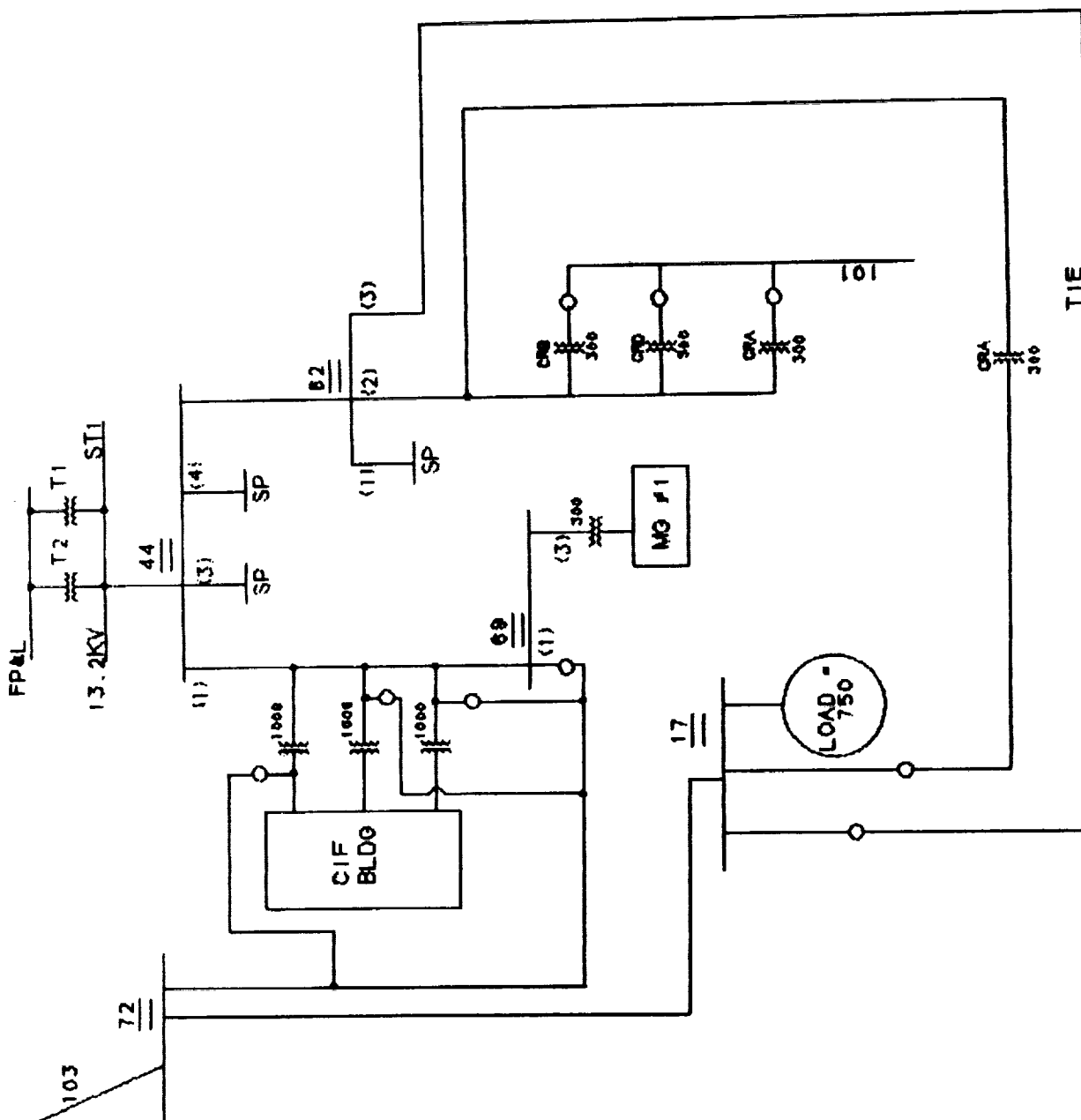


FIGURE 11

## FEEDER 102



**FIGURE 12**

# **TABLE I**

## **NORMAL CONFIGURATION LOADS ON THE LOAD BREAK SWITCHES AT THE ORSINO SUBSTATION**

<b><u>Lbs #</u></b>	<b><u>Supply Feeders</u></b>	<b><u>Adjacent LBS #s</u></b>	<b><u>Total Connected Load Under Normal Configu- ration</u></b>	<b><u>Added Load-if Failure Occurs Above LBS # - on Feeder</u></b>	<b><u>Special Features, Comments</u></b>
<b><u>Feeder 206</u></b>					
48	206 211 VIA LBS #47 609 VIA LBS #47	61, 47	15	Only single failures are considered. 112.5-61-206 612.5-OCR10-206	Tie point of 206 to 211 and 609
61	206	54, 58	127.5	500-OCR10-206	
55	206	54	2265		
15	206	54	2750		
54	206	T6,15, 55,61	5642.5		This is feeder 206.
<b><u>Feeder 211</u></b>					
37	211 VIA OCR 14 201 VIA OCR 13	36,51	1900		This is a load bus. Connected load is shared by feeders 211 and 201.
36	211	10,37,51	15 1900 <sup>1</sup>	300-51-201	Tie point of 211 to 201.
10	211	52,36	217.5	300-51-201	
52	211	9,10	480 1900 <sup>1</sup>	300-51-201	
47	211,206,609 VIA REG	73,48,730		15-73-211 90-53-211 15-48-206 127.5-61-206 627.5-OCR10-206 (C-5 not studied)	This is tie bus. 206/211 tie; and ORSINO/ C-5 tie.
73	211	53,47	15		

53	211	9.73	90		
9	211	T5,53, 52	570 1900 <sup>s</sup>	300-51-201	This is feeder 211.
<b><u>Feeder 207</u></b>					
60	207, 208 VIA LBS#5	45,5	1500	Only single failures are considered.	Tie bus for 207 to 208.
45	207, 209 VIA LBS#4	T5,60,4	7975	Only single failures are considered.	Tie point of 207 to 209. This is feeder 207.
<b><u>Feeder 201</u></b>					
35	201	59,34	2500		Load bus end of 201
59	210 VIA OCR 12 208 VIA OCR 7	34,23,35	150, 2500 <sup>s</sup> 325 <sup>s</sup>	587.5-23-208 6388.5-20-208 8638.5-21-208 10638.5-76-208 <del>225-34-201</del>	Tie bus, 201/208 tie
34	201, 208 VIA OCR 11	28,59,35	225 2500 <sup>s</sup>	150-59-208 <del>587.5-23-208</del> 6388.5-20-208 8638.5-21-208 10638.5-76-208	
37	201 VIA OCR 13 211 VIA OCR 14	51,36	1900		Load bus shared by feeders 201 and 211.
51	201, 211 VIA OCR 13	28,37,36	300 1900 <sup>s</sup>	15-36-211 217.5-10-211 262.5-52-211	Tie point of 201 to 211
28	201	27,51,34	3475 1900 <sup>s</sup> 150 <sup>s</sup>	SEE LBS#59 SEE LBS#51	Failure above LBS#28 maybe assisted by 211 VIA LBS#36 or land by 208 VIA LBS#23.
27	201	78,28	5725, 1900 <sup>s</sup> 150 <sup>s</sup>	Same as for LBS#28.	Same as for LBS #28
78	201	26,27	5800 1900 <sup>s</sup> 150 <sup>s</sup>	Same as for LBS#27.	Same as for LBS #27



26	201	25,78	6525,78 1900s 150s	Same as for LBS#78.	Same as for LBS #78
25	201	24,26	7525 1990s 150s	Same as for LBS#26.	Same as for LBS #26
*24	201	74,25	8275 1900s 150s	Same as for LBS#25.	Same as for LBS#25
75	201	74	2000		
74	201	39,75,24	10275 1900s 150s	Same as for LBS#24.	Same as for LBS#24
39	201	T5,74	10775 1900s 150s	Same as for LBS#74.	This is feeder 201.

#### Feeder 210

6	210, 208 VIA LBS#5	7,5	300		Tie point of 210 to 208
7	210	46,6	1475		
46	210	3,7	1887.5		
3	210	49,7	2187.5		
49	210	1,3	2532.5		
12	210	11	800		
11	210	2,12	912.5		
2	210, 209 VIA LBS#4	1,11	1827.5	Only single failures are considered.	Tie point of 210 to 204
1	210	T4,2,49	4360		This is feeder 210

#### Feeder 202/203

68	202/203	19	2500	
65	202/203, 204/205 VIA LBS#63	19,63	1500	2000-63-204/205

57	202/203, 204/205 VIA LBS#58	19,58	950	1050-58-204/205	
19	202/203, 204/205 VIA LBS#18	T4,57, 65.68,18	8175	7850-18-204/205	
13	202/203  <u>Feeder 208</u>	T4	4000		
43	208	42	75		Load Bus, end of 208
42	208	41,43	375		
41	208	40,42	400		
40	208	23,41	475		
23	208, 201 VIA OCR 8	20,40,59	587.5 325'	150-59-201 2650-OCR11-201 2875-34-201	Tie point of 208 to 201
22	208	20	1001		
20	208	21,22,23	6388.5 325'	Same as for LBS#23	
21	208	76,20	8638.5 325'	Same as for LBS#21	
77	208	76	2000		
76	208	56,77,21	10638.5 325'	Same as for LBS#21	
60	208, 207,209 VIA LBS#45	5,45	1500	Only single failures are considered	Tie point 208 to 207 VIA LBS#45. Failure above LBS#60 on 208 can be assisted by 207 and/or 209.
5	208, 210 VIA LBS #6	56,60, 6	1750	300-6-210 1475-7-210 1887.5-46-210 2187.5-3-210 2532.5-49-210	Failure above LBS#5 on 208 can be assisted by 210 VIA LBS#6 or by 207; 209 VIA LBS#45.

56	208	T3,5,76	11638.5 3257	SEE LBS#23, LBS#5	This is feeder 208.	
<u>Feeder 209</u>						
4	209, 210 VIA LBS#2 201 VIA LBS#45	T3,2,45	2100	6975-45-207 1827-5-2-210	This feeder is mostly a redundancy for feeders 210 and 207.	
<u>Feeder 212/103</u>						
17	103,212, 102 VIA LBS#62	72,62	1000	300-62-102	This is feeder 212 in parallel with feeder 103.	
72	103,212, 102 VIA LBS#69	T1,T3, 17,69	1000	300-62-102 300-69-102 3300-44-102		
<u>Feeder 204/205</u>						
67	204/205	18	2400			
63	204/205, 202/203 VIA LBS#65	18,65	2000	1500-65-202/203		
58	204/205, 202/203 VIA LBS#57	18,57	1050	950-57-202/203		
18	204/205, 202/203 VIA LBS#19	T3,58 63,67,19	8750	8075-19-202/203		
16	204/205,	T3	225			
14	204/205	T3	3500			
	Feeder Total		12475	Feeder 204/205		
<u>Feeder 101</u>						
T1	101, 102 VIA LBS#62	62	1100	Only single failures are considered.		
<u>Feeder 102</u>						
62	102, 103 VIA LBS#17	44,17	300	1100,101 750-17-103		

69 102,  
103 VIA LBS  
#72

44,72 300

Only single  
failures are considered.

44 102

T1,T2,  
69,62 3600

#### **IV RESULTS AND DISCUSSION**

**The information obtained from this investigation is presented in table 2 through 5. This can form the bases for a decision on where any additional load to the system can be made. Much of the information such as comparing demand to connected load are relevant only to the extent that it can help the system planning engineers to shape his/her engineering judgement. It is also important that the power coordinator pays attention to this data not necessarily to achieve higher system reliability, but to assure system optimal use and longevity.**

**To err on the side of safety, conservative assumptions are used to estimate quantities when there is no data to enforce precision. For instance, if a load is shared by two feeders, the shared load is added in full to compute the total load connected to each of the feeders. Also, since there is no demand data for the primary transformers the demands for the feeders connected to each primary transformer is added to estimate its demand as if those feeders peak simultaneously. Once more, it should be noted that all data are based on the system normal configuration and thus results obtained depict the worst case situations. The actual system reliability status is improved by the presence of redundancies and assist tie lines.**

**TABLE 2**

**CONNECTED LOAD -- DEMAND TABLE FOR FEEDERS**

<b>FDR</b>	<b>CONNECTED LOAD</b>	<b>DEMAND AUGUST 1988</b>	<b>MARGIN</b>	<b>DEMAND AUGUST 1989</b>	<b>MARGIN</b>
206	5642.5	1750.60	3891.90		
211	570 1900 <sup>1</sup>	976.97	1493.03		
207	7975	1188.55	6786.95		
201	10775 1900 <sup>5</sup> 150 <sup>6</sup>	2523.96	10301.04		
210	4360	1498.74	2861.26		
202/203	12175	4006.33	8168.67		
208	11638.5 325 <sup>7</sup>	2840.08	9123.42		
209	2100	853.54	1246.46		
212/103	1000	151.67	848.33		
204/205	12475	4417.27	8057.73		
101	1100	8.67	1091.33		

**TABLE 3**

**CONNECTED LOAD -- DEMAND TABLE FOR PRIMARY TRANSFORMERS**

<u>T#</u>	<u>CONNECTED LOAD</u>	<u>DEMAND AUGUST 1988</u>	<u>MARGIN</u>	<u>DEMAND AUGUST 1989</u>	<u>MARGIN</u>
T6	5642.5	1750.60	3891.90		
T5	21370	4689.48	16680.52		
T4	16535	5505.07	11029.93		
T3	27538.5	8117.02	19421.48		
T2+T1	5700	617.77	5082.23		

**TABLE 4**

**PRIMARY TRANSFORMERS: SIZE VS CONNECTED LOAD**

<u>T#</u>	<u>SIZE</u>	<u>CONNECTED LOAD</u>	<u>MARGIN</u>
T6	10000/12500	5642.5	4357.5
T5	10000/12500	21370	-11370
T4	10000/12500	16535	-6535
T3	10000/12500	27538.5	-17538.5
T1+T2	5000	5700	-700

**TABLE 5****PRIMARY TRANSFORMERS: SIZE VS DEMAND TABLE**

<u>T#</u>	<u>SIZE</u>	<u>DEMAND</u> <u>AUGUST 1988</u>	<u>MARGIN</u>	<u>DEMAND</u> <u>AUGUST 1989</u>	<u>MARGIN</u>
T6	10000/12500	1750.60	8249.40		
T5	10000/12500	4689.48	5310.52		
T4	10000/12500	5505.07	4494.93		
T3	10000/12500	8117.02	1882.98		
T1+T2	2500+2500	617.77	4382.23		

**Orsino (Industrial Area) Substation Total Data:**

**Capacity = 45000 KVA**

**Connected Load = 76786 KVA**

**Capacity-Load Margin = - 31786 KVA**

**Demand: August 1988 = 20679.94 KVA**

**Capacity-Demand Margin = 24320.06 KVA**

**The above information showing demands (also in tables 3 and 5) is based on the assumption that peaks on all the feeders occur at the same time which is a very unlikely event. It is only used to estimate the worst case scenario. In fact, the system history reveal that no two feeder demands (Peaks) have ever occurred at the same time.**



## **V CONCLUDING REMARKS**

**The data obtained during this study show that the industrial area (Orsino) Substation is healthy and reliable. There is a substantial margin between capacity and demand. History also does not show any need for additional protective devices or further redundancies.**

**However, the data reveals that loads have been added arbitrarily or perhaps based on geographic convenience (or associated costs) only, during growth. This philosophy does not lead to optimal system performance. The reduction or even elimination of outages should not be the only concern in power system operation. Well coordinated power and proper load distribution enhance several good results. The information such as contained in this report should be useful for making such decisions.**

**It will be desirable if a similar study is performed on the C-5 substation and thus on the entire 60-HZ power system. This could form the basis for a formal power systems planning here at K.S.C. This is needed in a rapidly growing facility such as K.S.C. With anticipated ever growing load, arbitrariness may lead to very poor results.**

**The initial intentions of this researcher was to do a classical load flow analysis and reliability analysis on the 60-HZ power system at K.S.C. The system which was constructed over twenty five years ago has undergone a lot of growth. Numerous load break switches have been added resulting in a new configuration. The diagrams shown in this report are based on the present system configuration.**

**However, data on the present form, such as the impedances of the lines from bus to bus are still being constructed. This made it impossible to perform a classical power flow analysis on the system. Further, the contractor, EG&G, that operates the system recently acquired a new package EDSA which is capable of performing such an analysis. Also, lacking at present is a complete inventory of component reliability parameters such as failure rates and repair rates. These are essential inputs for a classical system reliability analysis. These classical studies could not be performed at this time for the above reasons.**

**With the system being as healthy and reliable as it is; the capacity - demand margin being very substantial and history showing no reason for immediate concern. Attention can be shifted to the effects of future growth. None the less, the author would still suggest that meter readings be taken at the Primary transformer levels and isolation devices be placed above several load break switches.**

## **REFERENCES**

- 1. GP-900 Revision A - 60 Hz Power Systems Integrated Plan - Prepared by Planning Research Corporation Systems Services Company, May 1983.**
- 2. 79K17429 - KSC Power Distribution One-line Diagram - Prepared by EG&G Florida, September 1987.**